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Section 3
Infrastructure Requirements for the Creation, Management, and Use of Digital Data

1.0 -- Introduction

The DoD Desktop Guide for CALS Implementation provides decision templates for selecting the most effective digital data formats and media for technical data delivery. Effective acquisition and use of digital data can only be accomplished with full consideration of the ability of the activities to receive, store, distribute, and use the digital data.

The defense system program office must ensure that all recipients of digital data will have the capability to receive, store, and maintain the provided data. The materials and equipment required for receiving, storing, and maintaining data constitutes the infrastructure requirements of Continuous Acquisition and Life-cycle Support (CALS). This infrastructure requirement is a key consideration in implementing the CALS strategy on any defense system acquisition. Deficiencies in the Government's infrastructure may require investments by the Program Manager to implement the CALS strategy effectively.

All major system acquisition support activities should plan for CALS implementation as part of their initial program acquisition strategy. This planning includes the program strategy for funding necessary for: interfacing hardware; specific program application software; data conversion; and training. This section links selected digital data and media formats to the appropriate infrastructure requirements.

1.1 -- Purpose

This section is intended to provide Program Managers with an overview of hardware, software, and telecommunications requirements for the creation, management, and use of digital technical data. Paragraph 2 discusses the general considerations and requirements of a computer system infrastructure. Paragraph 3 describes the specific requirements that are dependent on the data type, data format, and user function.

1.2 -- Infrastructure Resource Planning

The Program Manager should plan infrastructure implementation such that funding can be set aside to be used when the infrastructure investment is required. This approach will better utilize program funding and resources.

2.0 -- General Considerations

If data users do not have access to the appropriate hardware, software, and telecommunications equipment; working in a digital data environment can become an obstacle course. In the past, Program Managers have contracted for digital data deliverables only to find an inadequate or nonexistent digital data infrastructure capability. The computer hardware must have the appropriate processing speed and display capability to run the application software adequately. The application software must perform specific tasks on the digital data that are required by the user. Rather than re-create the data, the appropriate computer networking system should allow the users to share data and resources, and telecommunications equipment should allow users to transfer digital data easily.

After reading the Desktop Guide, a Program Manager should have an implementation approach for data type, process, format, and delivery/access method. With this information, infrastructure requirements can be identified. Each decision will affect the life-cycle costs of a program and the cost of the program's computer infrastructure. Human-interpretable data formats, such as Page Description Language (PDL) and raster, may not be suitable as source data for other applications. Processable data formats can be integrated with other digital data to reduce the total life-cycle costs.

The following topics are addressed as considerations for a computer infrastructure:

- Computer Architecture
- Computer Operating System
- Storage Devices
- Output Devices
- Computer Graphics and Monitors
- Network Devices
- Application Software
- Software Licensing
- Local Area Networks (LANs)
- Wide Area Networks (WANs)
- Network Protocols
- Automated Information Systems (e.g., JCALS, JEDMICS)
- Internet/Intranet
- Security

2.1 -- Hardware Considerations

Computer hardware consists of the computer processor, memory, monitor, storage devices, input devices, and other peripheral devices. Each computer should be tailored to fit the need of the main application. Computational intensive applications such as mechanical solid modeling or engineering simulation will require a larger amount of memory than general text and 2-D graphics-based applications. Each application requires a distinct amount of hard disk space for data storage. Raster images and simulation models tend to require more disk space and faster processing than vector-based databases such as Computer Graphics Metafile (CGM) or Computer Aided Design (CAD) files.

2.1.1 -- Computer Architecture

Most engineering and business single user computers use either an 80486, 68CL040, Pentium (P5), PPC601, or a Reduced Instruction Set Computer (RISC) based processors. Each computer is designed to meet a specific requirement. In many cases, the computer architecture is driven by the choice of application software needed to perform a specific task. For this reason, the software selected may be the most important decision made.

The Personal Computers (PC) are the most widely used computers and are ideal for non-computational intensive applications that require low- to medium-graphic displays. The RISC workstations are widely used in engineering and technical publishing applications that require either a powerful processor for extensive calculations or a high-resolution graphics display for document editing. A "diskless" RISC workstation may provide a low-cost solution to some engineering computing needs. These workstations typically have a small hard disk for the operating system while the application software and user files are loaded from a server workstation that is connected by a network. A third option is a graphic display workstation that supports the X-window Motif standard. However, a PC with X-window emulation software may provide the same features at a lower cost. The standard options for minimum, recommended, and RISC computers are presented in Table 3-1. The minimum configuration describes the minimum capabilities that should be available on existing workstations and the recommended configuration is intended for new computer purchases.

	PC Workstation Minimum Configuration	**PC Workstation Recommended Configuration**	**RISC Workstation**
Processor	486 DX -- 66/68LC040	P5-133/PPC 601	RISC Workstation
L2 cache	256K	256K	
System memory	16 MB	16 Mb	32 Mb
Expansion bus	PCI and ISA	PCI and ISA	
Sound card	16-bit FM -- Optional	16-bit FM	
Graphics Memory	1MB DRAM -- Optional	2MB DRAM or VRAM	
Media			
Hard Drive	540 MB	1 GB	500 MB
Floppy Drive	3.5*	3.5*	3.5*
Tape Drive	Optional	Optional	Yes
CD Drive	4X CD-ROM	6X CD-ROM	Yes
WORM	Optional	Optional	Optional
Modem	14.4-Kbps	28.8-Kbps	Optional
Monitor	14-15" SVGA 0.28dpi	17" SVGA 0.28dpi	19"-21" High Res
Typical Cost	$800 to $1,200	$2,000 to $4,000	$5,000 to $50,000

* -- At least one machine in office area should have a 5.25" Floppy Disk Drive

Table 3-1. -- Standard Options for PC Types.

2.1.2 -- Computer Operating System

The operating system is the shell that interprets the user's commands and translates them into machine code to control the computer's resources. The computer's internal clock, memory, Central Processing Unit (CPU), terminal, and other peripherals are controlled by the operating system. The three major distinctions among operating systems are the internal throughput bit size, the amount of available memory, and the ability for multitasking. Each of these factors controls the effectiveness of a computer for a particular user.

Most PCs have a 32-bit internal bus as do most RISC workstations. A few of the high-end RISC workstations have a 64-bit internal bus and will be compatible with a 64-bit operating system.

Several operating systems are available for 80486 and P5 based PCs. Disk Operating System (DOS) was the first major operating system for a PC and continues to be the standard. DOS is only an 8-bit or 16-bit operating system and does not offer true multitasking. OS/2 (now OS/2 Warp) was introduced a few years ago and offered users multitasking and a 32-bit operating system. Windows NT is similar to Macintosh Operating System 7.5 (see next paragraph) and offers many advantages compared to DOS. The largest benefit is that Windows NT is available on PCs and RISC-based workstations. This allows the engineering users access to the same application software on a RISC workstation that most business users have on a PC. While Windows 95 is a new 32-bit operating system for PCs, it also includes 16-bit code that will allow it to work with existing Windows 3.x- and DOS-based applications.

A popular operating system used for the Macintosh 68000 series and the Macintosh PPC 601 processors is Macintosh Operating System 7.5, which is a true windowing system with 32-bit multitasking capabilities. This operating system has attained popularity due to its ability to meet the demands of both beginner and expert computer users. The operating system has strict hardware/software standards that reduce compatibility and installation problems, although the cost of this system is generally higher than similar Windowing systems.

In a RISC machine, the instruction set contains simple, basic instructions, from which more complex instructions can be composed. Most instructions are completed in one machine cycle, which allows the processor to handle several instructions at the same time. This pipelining is a key technique used to speed up RISC machines. Most RISC workstations currently have a UNIX operating system based on System V UNIX or Berkeley BSD 4.4 UNIX that is POSIX compliant. Each operating system provided with RISC workstations is unique, but most will run application programs that were compiled using System V or Berkeley BSD UNIX.

OSF/1.0, OPEN VMS, and Windows NT are operating systems that are designed to allow users a greater variety of application software. Windows NT is designed to allow users of the RISC-based computer and 80486-processor-based-computer to run the same operating system and the same versions of application software.

Keep in mind that integral to the operating system choice is the make and sometimes model of the platform used. Different platforms running the same operating system will sometimes require translation or conversion of programs before they will run on an alternative platform. For example, programs designed to run in an Oracle database on an HP file server must be "ported" to DEC or SUN or any other make to allow it to operate. This adds cost and schedule considerations to the effort.

2.1.3 -- System Backup

System backup is very important to the Program Manager. If managed properly, systems can be designed such that even a catastrophic loss of data can be recovered in a relatively short period of time. To do this, the Program Manager should address areas such as hard drive or CPU failure, lightning strike, fire, or damaging storm in a disaster recovery plan. A common means to archive system and program data is to use a tape backup system. The backup system should also be tested to make sure it works properly.

2.1.4 -- Data Storage

Each computer system needs the appropriate amount of data storage capacity to allow users access to all areas of project data. This disk space can reside on each computer or on a network file server. Storage technology is constantly changing, and the Program Manager should understand that the physical media addressed below is provided as a guideline but does not necessarily imply that only the following technology should be used in building infrastructure. When evaluating whether to use new technology, the Program Manager should assure compatibility with other equipment of the same technology or with older, less sophisticated media.

2.1.4.1 -- Magnetic Media

Magnetic disk drives (hard drives) are available for most computer systems. Magnetic disk drives can store from 200 to 4,000 megabytes and should be American National Standard Institute (ANSI), SCSI, or IDE compatible. SCSI provides compatibility and allows for expansion when greater disk space is required.

Magnetic disks can be used to transfer data when required. The most common magnetic disk used to transfer data are the 3.5 inch diskettes. The 3.5 inch can hold up to 4 Mb of data; however, 1.44 Mb diskettes are more prevalent. Using magnetic disks to transfer data should only be considered when the total data does not exceed 10 Mb.

When transferring over 10 Mb of data, a 9-track computer tape or Quarter Inch Cartridge (QIC) tape would be better suited (see MIL-STD-1840). The standard 9-track tape can store approximately 240 Mb of data compared to 500 Mb with the QIC. The exact configuration of the tape format can greatly affect the capacity of the tape. Tape drives that accept tape cartridges are easier to obtain and integrate into a desktop computer system. However, the Program Manager should confirm that tape formats are compatible.

An alternative technology to 9-track tape or an optical drive (paragraph 2.1.4.2) is the Digital Audio Tape (DAT) drive. DAT drives can store up to 5 Gigabytes (G-byte) of data. The tapes are small and are easily integrated into the desktop environment. This avoids capacity problems that are sometimes encountered in 9-track and optical drives.

2.1.4.2 -- Optical Media

Optical drives are readily available and come in many different types and sizes. The most common optical drive is the 5.25 inch Compact Disk (CD) Read Only Memory (ROM) drive. These drives are used for end user systems similar to the Advanced Technical Information Support (ATIS) system (see Appendix **Naval Forces**). A Write Once/Read Many (WORM) optical disk system should be considered for storing the final deliverable digital data for a large project. CD-ROMs typically store 740 Mb of data, and 14" optical platters can store up to 200 G-bytes. This will provide the project with a non-erasable copy of the data that can help in configuration control. However, all WORM optical disk systems do not produce the same format as CD, and compatibility with the end user should be verified.

2.1.5 -- Output Devices

Each computer user will need access to a printer. Users involved with the creation or use of engineering drawings and information may also require access to a plotter. These devices can be set up on a Local Area Network (LAN) rather than directly to a specific computer, so that network users can share the devices. Printers are generally used to produce "A" (8.5" x 11") or "B" (11" x 14") (ANSI Y14.1-80) size documents. Plotters are used to create up to "J" size documents. Aperture card plotters are also available and are used to plot the image to an aperture card and inscribe the aperture cards keypunch data.

An "A" size PostScript compatible laser printer is the standard printer recommended for general use. The printer should have a minimum resolution of 300 by 300 Dots Per Inch (DPI) and a minimum print speed of four to eight pages per minute. An "A/B" size laser printer would be suitable for printing engineering drawings. Most drawings are legible when printed on "B" size paper.

The two main types of plotters are electrostatic and pen plotters. Electrostatic "E" size plotters are recommended for engineers involved in the creation and review of engineering documents or when there is a requirement to plot up to "E" size raster drawings. A pen plotter may suffice, but these plotters can take up to 30 minutes to print a vector drawing versus only 1 to 2 minutes for an electrostatic plotter. Pen plotters cannot be used to plot raster images. Electrostatic plotters generally cost between $5,000 and $12,000; pen plotters cost about $4,000.

2.1.6 -- Computer Monitors

The resolution and monitor size are important considerations when choosing the proper monitor. A 15- to 17-inch monitor is suitable for general Windows applications, but is not recommended for reviewing drawings or illustrations. Most users who work with graphical data such as engineering drawings or technical illustrations will be more efficient with a high-resolution, 19-inch monitor. This is especially true when working with raster files. A larger monitor may eliminate the need to zoom in on a section of the drawing or illustration.

2.1.7 -- Graphics Processors

An option for some RISC-based workstations is real-time, 3-D graphic manipulations. This allows the user to rotate and/or scale the view of the object in real time. Any engineer performing solid modeling or finite element analysis will increase productivity on the workstation with this option. Screen redraws for complex images can take up to several minutes with a standard graphics option but can be performed instantaneously with the 3-D graphic processors.

2.1.8 -- Network Devices

Network devices include equipment that is required to connect a single user station to an existing network or to connect two or more networks together. Examples of this type of equipment usually are network cards, bridges, and routers.

The basic requirements for creating a single LAN are a Network Interface Card (NIC) and the appropriate cable (e.g., an Ethernet board for each computer and the coaxial or twisted-pair cable to connect each computer). Network bridges can be added to the LAN, to connect to other LANs or manage the LAN electronic message traffic. A bridge is a network relay that reads, buffers, and sends data to relay it from one data link to another, but makes the two data links appear as one to levels higher than the data link layer. Network terminal servers allow terminals, modems, and printers to be connected into the LAN. A router is another type of network "relay" that uses a protocol beyond the data-link protocol to route traffic between LANs and other network links. Network routers enable remote LANs to be connected or the

LAN to connect to a Wide Area Network (WAN).

All network devices should support the Ethernet V2.0, Institute of Electrical and Electronic Engineers (IEEE) 802.2 and 802.3 standards. Due to LAN configuration complexity and variety, the Program Manager should discuss infrastructure requirements with the supporting activity Automated Data Processing (ADP) manager before purchasing any network equipment.

2.1.9 -- Input Devices

There are many different ways to provide input to a computer system. One of the most basic input devices is a keyboard. While there are many different arrangements, the industry standard is the 101-key type. Additional devices include mice, track balls, digitizing tablets, light pens, and scanners. With the exception of the scanner, all the previous devices generate data with the user's guidance.

2.1.9.1 -- Scanners

Scanners are the means by which paper or aperture card information is converted into digital format. The technology of scanners has greatly increased in the past few years and can add speed in the generation of technical data. Scanners can have many features including color, gray scale, line art, and a host of others. As a general rule, the more features and higher resolution of the image, the more disk space is required. There are definite ranges where there is a point of diminishing return comparing quality of image vs. size of image. Attention should be paid to this aspect, because, not only will a large image consume a large amount of disk space, but it will also slow the speed of the computer when the graphic is to be displayed. There are many different types and sizes of scanners available to the Program Manager. The two basic types of scanners are page scanners and large-format scanners.

Page scanners are designed to be implemented with text or graphics up to 8.5 by 11 inches. When scanning images for documents that are currently being created or updated, a single-page scanner should work well. An automatic document feeder should be considered for large volumes of paper data. Features for a single-page scanner include quality of scan and moderate speed.

Large-format scanners are used to generate raster images from paper drawings up to 60 inches wide with an unlimited length. The scanners are monochrome/gray scale and are a single-sheet feed operation. In recent years, the speed and cost have been significantly reduced while quality has been enhanced. Large-format scanners can provide a means of converting old, deteriorating paper drawings into an electronic form that can be edited and restored, if required. Many activities and sites are currently using scanners. Although the cost has been reduced significantly, a large-format scanner is a major investment and is usually purchased by the software support activity as a shared resource.

The 360 Defense Printing Service (DPS) sites support all the Services and can provide scanning services. Joint Engineering Data Management Information and Control System (JEDMICS) sites have large format and aperture card scanning capability. Program managers should consider these organizations for large format or aperture card scanning in order to avoid the cost of purchasing expensive, specialized equipment.

2.2 -- Software Considerations

The Program Manager must consider how specific software applications fit into the complete data process. Configuration management software may be needed to control the access and revision of digital data files as well as the specific application software. Software applications and repository services available through Automated Information Systems (AISs) such as JEDMICS should be considered before different software applications are examined. Another important question is whether the software import and export files are or should be in a CALS format such as MIL-PRF-28000 Initial Graphics Exchange Specification (IGES) and MIL-PRF-28001 Standard Generalized Markup Language (SGML). Due to the multitude of available GOTS and COTS software, the key consideration becomes seamless integration of applications for ease of use and ensuring functional requirements are met by the selected software.

2.2.1 -- Data Formats

Digital data deliverables available in the CALS environment are extensive. The Program Manager must determine which format is appropriate at each stage of a specific program. The final deliverables could be in a standard CALS format while preliminary digital data may be in a Mutually Agreeable Commercial Software (MACS) format that is agreeable to the Program Manager and the contractor. Commercial word processing software with the capability of text attribute, style sheets, and imbedded graphics may be used to view and annotate preliminary TMs/TOs. In general, the data needed for sustainment of a weapon system needs to be created in a standard or mutually acceptable format so that minimal data conversion will be required later on. A list of various digital data formats is shown in Table 3-2.

The Program Manager must consider who is going to use the data and ensure that the infrastructure matches each user's data use requirements.

Standard Digital Data Formats:
MIL-PRF-28000 IGES
MIL-PRF-28001 SGML
MIL-PRF-28002 Raster graphics
MIL-PRF-28003 CGM for illustration data
Formatted American Standards Code for Information Interchange (ASCII) text
Page Description Language POSTSCRIPT
VHSIC Hardware Description Language (VHDL)
Electronic Design Interchange Format (EDIF)
Institute for Interconnecting and Packaging (IPC-D-350)

Portable Document Format (PDF) -- Adobe Acrobat (defacto standard)
IETM format (MIL-PRF-87278, -87269, SGML, PDF, etc.)
Native data format (e.g., CAD, word processing, etc.)

Table 3-2. -- Standard Digital Data Formats.

The required infrastructure will vary depending on the data use and the data format. Formats, such as MIL-PRF-28002 Raster, will require a higher resolution monitor but less processing capability to view and modify compared to a solid-model-based CAD system. Raster and MIL-PRF-28000 IGES data formats generally necessitate larger disk memory. Some data functions cannot be performed on all digital data formats.

2.2.2 -- Operating System Compatibility

The first consideration is which operating systems the program uses. The operating system variations are described in 2.1.2. A software application that supports multiple workstation types will allow greater flexibility than a program tied to a single operating system. This is especially true when business and engineering personnel need to review the digital data. Most business applications operate on a PC while most engineering applications operate on RISC-based workstation.

X-window emulation software may solve some problems. The current generation of X-window emulation programs are quite robust and can be used to allow PC users access to UNIX X-window software from a PC. The PC emulation packages for RISC-based workstations are not as sophisticated as the X-window emulation programs.

2.2.3 -- Application Packages

General types of packages of application packages are shown in Table 3-3.

Computer Software	Capabilities	Examples
Word Processing	Creating Text-Based Doc.	Documents
Spread Sheet	Calculations Data Manipulations Chart and Graphs	Financial Reports Engineering Calculations Data Reports
Databases	Store and organize data Reports Queries	Data Reports

Workflow Manager	Route data to reviewers Define, activate, and monitor jobs and processes	Data Deliverables
Electronic Mail	Exchange mail messages and data files	Administrative Data
Desktop Publishing	Advanced Text and Graphics Integrated Documents	Advanced Documents and Publications
Multimedia	Audio/Video/Animation Advanced Text and Graphics Hypertext	Training Materials IETMs
Mathematics	Symbolic Calculations Advanced Calculations 2-D, 3-D Plots	Engineering Calculations Technical Reports
Terminal Emulation	Emulates Specific Terminals for PCs	X-Window Emulation on a PC
MCAD	3-D Solid Modeling Mechanical Drawing	Weapon System Models Ship Drawings
Schematic Capture	Electrical Schematic Logic Checking	Wiring Diagrams Avionics System Designs
Printed Wiring Board (PWB) Layout	PWB Layout PWB Manufacturing Data	Computer Aided Manufacturing
Finite Element Analysis	Structural Simulation Vibration Simulation Thermal Simulation	Flight Safety Checks Cooling Systems Evaluations
Dynamic Simulation	Mechanism Simulation Dynamic System Simulation	Bomb Rack Mechanism Evaluations Vehicle Characteristic Simulations
Electrical Simulation	VHDL Analog Simulation ASIC Simulation	Computer Aided Engineering

Table 3-3. -- General Types of Application Packages.

2.2.4 -- Software Licensing

The type of software licensing available can affect the total cost to implement a software system. The four types of software licensing that are prevalent today are single-user license, single-computer license, network license, and a site license. Each licensing option has a proper use and can greatly affect the total life-cycle costs associated with the software procurement.

A single-user license allows the software to be loaded on one computer, and one person has access to the program at a time. Most PC software programs are licensed to a single user. A single-computer license is licensed for a specific computer, and the vendor may charge to move the license to a different computer. This type of license can allow either a single user or multiple users access to the program. The multiple-user option is generally used when the software is operating on a mainframe computer or network server.

A network license will allow a specific number of simultaneous users, who share a common network, access to the program. Single-computer and network licenses are usually offered on software available on UNIX workstations. These licenses can reduce the total cost of supplying the needed software for all of the users of an acquisition program. A site license allows the software to be used on any computer at a particular location.

Next Section